

REMARKS

Claims 1, 5, 10-15, 17-22, 31, 32, 34, and 37 are pending. Claim 37 is allowed. The elected independent claims, Nos. 1, 31 and 32 have been amended to further define over the prior art. Dependent claims 14 and 15 have been amended in view of the changes to claim 1. Reconsideration and withdrawal of the rejections is respectively requested in view of the changes to the claims herein, and the following remarks.

A threshold issue is the interpretation of "diffusion" in the claims. As set forth in the application, e.g., at page 13, second paragraph, as used in the application and the claims, "diffusion" means movement of ozone in a defined direction, i.e., through the liquid boundary layer, and to the liquid/solid surface interface on the workpiece. Consequently, with "diffusion" as claimed, there is specific direction of movement, i.e., from high ozone concentration areas to low ozone concentration areas. Indeed, the scientific or chemistry based definition of diffusion relevant here is:

"The movement of chemical species (ions or molecules) under the influence of concentration difference. The species will move from the high concentration area to the low concentration area until the concentration is uniform in the whole phase." *Electrochemical Dictionary*, available at electrochem.cwru.edu/ed/dict.htm.

The rejected independent method claims, Nos. 1, 31 and 32, have each been amended to include this description of movement of ozone gas. While Applicant acknowledges the definition provided by the Examiner at paragraph 8 of Paper 18 (December 19, 2002 office action), Applicant submits that the cited Random House

College Dictionary, in this instance, provides a general non-scientific, and overly broad definition of "diffusion." In contrast, the definition set forth above relates more directly to the chemistry of the application, and is also much more consistent with the explanation of "diffusion" given in the application. The definition above is also more consistent with the meaning of "diffusion" in the application to a person of ordinary skill.

Turning to the prior art, EPO 782 177 A2 relates to etching of silicon oxide. After initial etching, an acid solution is used to complete the etch, all as part of a rinse step. Page 3, lines 50-55. Gases, such as HF, HCL, or ozone, are introduced and are absorbed by the water stream directed onto the wafer. Page 2, last line. The water stream absorbs the gas. Page 3, line 24.

Absorption is defined as:

"A process 'to take in and incorporate,' e.g., light can be 'absorbed' by a material. In chemistry, a term often used to describe the dissolution of a gas into a liquid or solid. The dissolving gas is said to be 'absorbed'." See the Electrochemistry Dictionary.

Thus, the gas in EPO 782 177 A2 dissolves into the liquid. There is no concentration gradient, induced movement of gas within the liquid from high concentration to low concentration areas. There is no diffusion. Consequently, EPO 782 177 A2, at a minimum, cannot render obvious the last step of claims 1, 31 or 32.

In addition, there is no discussion of a boundary layer, or control of boundary layer thickness, in EPO 782 177 A2. Indeed, the wafer is rotated in EP '177 simply to remove the liquid. Page 4, line 19. There is no discussion of spinning for any other reason.

While the Examiner is correct that EP '177 discloses use of ozone, it also expressly states that HF, not ozone, is the preferred gas. Page 3, lines 51-52. Hence, EP '177 teaches away from ozone.

Finally, with respect to EP '177, as noted by the Examiner at paragraph 2 of the May 5, 2003 final office action, EP '177 does not disclose use of heat, or heating a liquid. Indeed, since the stream of gas in EP '177 is absorbed or dissolves into the liquid (page 3, line 24), there would be no motivation to provide a heated liquid in EP '177. Since the solubility of virtually any gas, including ozone, in a liquid, such as water, decreases with increasing temperature of the liquid, the inherent suggestion in EP '177, is to use room temperature or chilled liquid. Consequently, EP '177 teaches away from the claimed heating steps.

JP '927 describes a method for washing a semiconductor wafer using ozone and sulfuric acid. (See the enclosed Translation ¶ 34.) In JP '927, there is no boundary layer of liquid. Rather, an ozone atmosphere (1) is provided around the wafers 4 within the tank 2. (Translation ¶¶ 29, 45, 46, 51.) The wafers and tank are preheated to 120°C. (Translation ¶¶ 55 and 60.) The surface of the substrate reacts directly with the ozone gas. After a certain amount of ozone is consumed in the organic material oxidation, nozzles spray hot sulfuric acid, optionally including water containing ozone, onto the wafers. (Translation ¶ 55.)

Thus, JP '927 discloses a two-step process:

(1) A dry oxidation process by exposing heated wafers directly to an ozone atmosphere, followed by:

(2) A hot sulfuric acid spray, which commences only after the atmospheric concentration of the ozone is reduced within the tank. (Translation ¶ 55.)

In contrast, amended claims 1, 31 and 32 describe diffusion of ozone through a heated liquid boundary layer, from a region of higher ozone concentration, to a region of lower ozone concentration. In JP '927, during the hot sulfuric acid spray step, even if significant amounts of ozone remain in the tank, there is no diffusion or movement of ozone gas through a liquid boundary layer, via a concentration gradient. Indeed, JP '927 teaches against an ozone concentration gradient, since the organic material on the wafer surface which reacts with or consumes ozone, is oxidized in the dry ozone oxidation step preceding the hot sulfuric acid spray step.

Nakajima et al. '367 describes dissolving an ozone containing gas into a bath of solution. (Column 3, line 56 – column 4, line 2; column 4, lines 62-64.) There is no suggestion in Nakajima et al. of diffusing ozone through a heated liquid boundary layer via a concentration gradient. Indeed, there is no liquid boundary layer at all in Nakajima et al., since the wafer is entirely submerged in a bath of liquid.

In addition, Nakajima et al. describes rotating a wafer to spin dry the wafer, but not to maintain a boundary layer thickness of heated liquid. The intent of the spin drying is to remove all of the liquid during a drying step. In contrast, the amended claims describe forming a boundary layer of heated liquid on the workpieces.

Accordingly, the amended claims cannot be obvious over the combination of EP '177, Nakajima et al., or JP '927, at least because none of these prior art references suggest the claimed diffusion step.

Regarding the principle reference EP '177, in the first office action mailed September 25, 2001, the Examiner applied EPO '596 as the principle reference for all rejections, with the Examiner commenting (at page 3) that "EPO '596 discloses all of the claimed subject matter with the exception of heating the workpiece." In response, Applicant pointed out that EPO '596 expressly teaches away from heating. The Examiner now applies EPO '177 as the principle reference. EPO '177 also teaches away of heating the liquid, although EPO '177 lacks the express statements against heating that are in EPO '596.

While the Examiner is of course free to apply any prior art as the principle reference, the Examiner's previous consideration of EPO '596 as the principle reference (both in this application and at least initially in 09/837,722, now U.S. Patent No. 6,601,594) suggests that EPO '177 may not be properly applied against the claims, because it is not the closest prior art. Indeed, the closest prior art, EPO '596 contains clear express statements teaching away from the claims.¹

Regarding the Examiner's comments at paragraph 9 of the May 5, 2003 final office action, Applicant agrees with the Examiner concerning the presence of contaminants on the surface of the wafers. However, the critical difference between the claims and the combination of prior art described at paragraph 9 of the May 5, 2003 final office action is that in the prior art, the gaseous chemical is dissolved or absorbed into the liquid, presumably up to saturation, i.e., a minimal concentration if the liquid is

¹ EPO '596 is also applied as the principle reference in the corresponding application in the European Patent Office, wherein comparable claims are allowed.

heated. The principle processing then occurs via a different chemical i.e., HF in EPO '177 (page 3, lines 51-52), or hot sulfuric acid in JP '927.

Regarding the rejections of claims 5, 12, 13, 15, 17, 18 and 22, Applicant submits that the picking and choosing of individual method steps from combinations of four or more prior art references, would not be obvious to a person of ordinary skill.

In view of the foregoing, it is submitted that the claims are in condition for allowance. A Notice of Allowance is requested.

Respectfully submitted,
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